STATISTICS EDUCATION AND THE COMMUNICATION OF STATISTICS: A REPORT ON THE IASE/ISI SATELLITE MEETING, 2005

Brian Phillips
Swinburne University of Technology, Australia
bphillips@swin.edu.au

The International Association for Statistical Education, IASE, has a very strong commitment to the general development of statistical educators including research and the sharing of ideas and experiences. In particular the IASE/ISI satellite meetings are always very friendly, informative affairs as was the one in Sydney April 4-5, 2005. The theme was Statistics Education and the Communication of Statistics, it was jointly organised by the IASE and the Victorian Branch of the Statistical Society of Australia and immediately preceded the ISI session in Sydney. The theme of the conference was chosen because some IASE members felt that the communication of statistical methods and results needed more emphasis in our courses and wished to draw the attention of statistics educators to this area to encourage development and innovation. This paper summarises the main points the speakers made and the main issues that emerged.

INTRODUCTION

Chris Wild, Past President of the IASE, said in his introduction: "Our theme is Statistics Education and the Communication of Statistics. It is impossible to overstate the importance of this theme. I have had a slogan that goes 'English in, English out.' It is not a conspiracy to promote the English language, but rather the idea that to be effective in the real world, our students will have to be able to take problems vaguely conceived in natural language terms through the statistical investigation and analysis cycle to arrive at conclusions that they can successfully communicate to others in natural language."

Some sixty participants enjoyed the twenty-four papers that were presented over two days, with some time for discussion and socializing. The papers presented at this meeting can be found at http://www.stat.auckland.ac.nz/~iase/publications.php?show=14.

The topics which emerged can be classified loosely as:

- Writing Reports of Statistical Studies
- The Role of Graphics in Communication of Statistics
- Outreach to Public and Schools
- Understanding the Language of Statistics

The keynote speaker, Stephen Fienberg got the proceedings off to a great start with his talk entitled "To Tell the Truth: What We Know About Lie Detection." In this stimulating presentation Stephen provided an overview of the U.S. National Research Council's Committee's work on the question "How good is the polygraph in detecting deception in such settings?" This issue is of particular importance these days with increasing terrorist activities and tens of thousands of individuals undergo polygraph security screening examinations in the USA every year. As he said, "assessing the statistical evidence regarding the accuracy of the polygraph was just the first part of the committee's job. We also needed to communicate the results of its assessments in a way that could educate the public and have maximal impact on public policy." What helped greatly with the acceptance of the report was the presentation of the results of 10,000 hypothetical populations as tables as frequencies, rather than more complicated ways such as by using probabilities, demonstrating the importance of communication readily understandable by the audience. A report of this report is discussed in Fienberg and Stern (2005).

WRITING REPORTS OF STATISTICAL STUDIES

A number of authors described how they make students write reports to help them learn how to communicate statistics.

Lipson and Kokonis discussed the implications of introducing report writing into an introductory statistics subject. Their exploratory study was designed to investigate the ability of

students in these courses to undertake a report writing task. It was found that students find such tasks quite difficult, and generally are able to gain higher marks on questions where they carry out standard analyses. They suggested that the report writing task may be classified as a metacognitive activity, and of itself provides a means of facilitating the development of conceptual understanding in students. One example given compared a standard exam question with one in which the emphasis was on report writing, rather than calculations. The reaction of many of those concerned with the teaching and assessment of this subject was that the new style of question was far too easy, since the students were not required to either select the test or carry out the analyses for themselves. However, Lipson and Kokonis' analysis suggested that this may not be the case. They concluded that there is "preliminary evidence that the challenge of the report writing task has encouraged students to take an holistic view of the processes that underlie statistical inference."

On a similar theme, Glenda Francis claimed that while there have been many improvements in the teaching of statistics over recent years, and an acknowledgement of the importance of being able to communicate results, little has been said on how to train students to write reports. If we want students to write effective reports on statistical analyses we have to include specific training on report writing as part of our subjects which must be integrated at all levels. Glenda gives students a framework around which to write their reports that leads them through the steps of selecting an appropriate analysis, reflecting on the results and writing a report. She makes the point that "if we want students to see communication of results as an integral part of statistics, we must include this in our assessments."

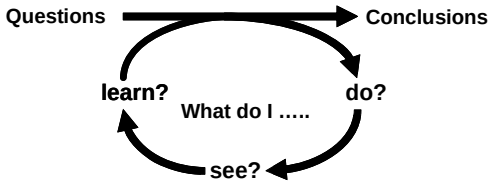
Helen MacGillivray also used ideas of report writing in her presentation, titled *Helping Students Find Their Statistical Voice.* She discussed and analysed strategies that she has integrated throughout her courses to help students develop their communication in, and of statistics - to themselves, with others. These included issues relating to communication both with graphs and about graphs, how students "need learning experiences within each of the three phases of exploration, presentation, analysis, and also integrated within larger whole contexts and data investigations that include analyses and reporting." Helen outlined an extensive program she has used for more than 10 years, with the aim of helping students to connect with statistics through ownership of their data by the use of projects, having used over 1500 projects with students from a number of disciplines. Communication of, in, and about statistics is integral throughout the projects. Particular emphasis is placed on thinking of one's reader, and ensuring that a reader knows exactly the circumstances and assumptions, so that the study/investigation can be repeated or extended or re-interpreted.

In Roxy Peck's presentation, *There's More to Statistics than Computation – Teaching Students How to Communicate Statistical Results*, she pointed out there is a growing trend, in the U.S. and elsewhere, to include interpretation and communication as part of student assessment in introductory statistics courses. For example in the Advanced Placement Statistics exam in the U.S clear and efficient communication are seen as essential aspects of data analysis, and Roxy points out it makes sense to look critically at introductory statistics courses to assess where these skills might be addressed and to consider ways in which statistical communication skills might be more effectively developed in students. This paper offered some suggestions for teachers of introductory statistics courses when reporting the results of a data analysis, including:

i. A good place to start is with a graphical display of the data.
ii. Emphasize the importance of context.
iii. Ask questions that require explanation and interpretation throughout the course.
iv. Don't accept "mechanics only" answers as correct on homework or exams.
v. Encourage students to read as well as write.
vi. Ask students to write about statistical processes.

Furthermore, Roxy made the point "while it may be painful to read students' early attempts, practice, consistent expectations and good feedback can produce rewarding results."

Forster, Smith and Wild in *Teaching Students to Write About Statistics*, describe systems they use to help students develop writing and communication skills. Their method involves getting students to be more active participants in a research cycle.



They use a two-stage process: firstly a "noticing phase" where the students concentrate on their computer output, and secondly where the primary messages from the output are communicated using everyday language. They have their students make *Technical Notes* which include reports of the Exploratory Analysis, Assumption Checking and Statistical Inference and an *Executive Summary* which is in non-technical language that should not contain any statistical terminology that would only be properly understood by a statistician. They a strength of their approach is that it makes it easier for students to learn how to structure a report but a weakness is that it is highly structured tending to stifle creativity in the report writing phase, though they pointed out they are a lot less rigid in higher courses as they believe the lessons from earlier courses give students enough guidance in communicating their findings in a sensible and comprehensible manner.

Prvan and Ascione had their students participate in a Virtual Chance Fair by producing and reporting on a web site they made to develop their statistical and communication skills**.** They claimed that the methods they used make communicating statistical findings much more straightforward for students.

ROLE OF GRAPHICS IN COMMUNICATION OF STATISTICS

While many authors used standard statistical graphics as important tools to help in the communication of statistics, several specifically designed graphics tools can help in this role.

Cumming and Fidler showed how they use specially designed graphics of interval estimates to help with understanding and communication of certain estimation methods. In particular they discussed some misconceptions about the relationships between hypothesis testing and confidence intervals. They demonstrated several dynamic graphic displays and gave some rules of eye for teaching deeper understanding of interval estimates. They see the need to assess the effectiveness of these rules, and displays, in helping students avoid, or overcome, the misconceptions held by many researchers.

In their paper aimed to demonstrate the effectiveness of graphical displays, Cunningham and Wang showed how Amos Graphics can be used to enhance the understanding and communication of multiple regression. Using examples drawn from standard multiple regression and hierarchical regression models, the authors compared the outputs from *SPSS* and *AMOS* graphical representations. They argue that the graphical interface of *AMOS* has the potential to enhance conceptual understanding and communication of results in undergraduate statistical courses, particularly in the social sciences where the large majority of students are visual learners.

Hilary Green introduced a graph she designed to display data obtained from surveys, opinion polls or evaluations which she calls Grapharti. She explained the intention of Grapharti is to enable people to derive further meaning from results of online surveys. Grapharti is not meant to be a scientific tool, but rather as one that facilitates exploration of the questions and responses. This is achieved by the design elements which provide the user with choices as to how the data are to be grouped and displayed. Grapharti presents the data as a picture, where the attributes of colour and size of each bar add meaning to the questions and it may be of use as a tool for data mining, which involves sorting through data to identify patterns and establish relationships.

Harold Henderson showed how data can be visualised with dynamic graphics now widely available in many statistical packages, including *Excel*. Data visualisation tools provide deep insight into the structure of data. He showed how data can be explored with dynamic graphics using filters and pivot tables and pivot charts. He gave examples of the use of these tools in statistical practice which are relevant, up-to-date and easy to understand. He also listed "The Best and Worst of Statistical Graphics site": http://www.math.yorku.ca/SCS/Gallery/.

Peter Martin explored the potential of enhancing effective communication of information arising from statistical analyses to a non-statistical audience using various graphical forms. He pointed out that we can learn a lot from the business world where often senior management don't have the time to wade through complex summary tables of statistical analyses. It is far more efficient to use good graphic displays in order to communicate the essential ideas. He concluded that "there is a need for some degree of creativity and lateral thinking on the part of the individual who wants to make the communication connection." The resulting graph may not be all that complex. Rather, it may simply be a different way of looking at some situation, or that a meaningful link has been made between graph form and statistical concept. Very often Peter has heard clients say "I wonder why nobody thought of that before?"

Larry Weldon argued for the use of simulation and graphical displays to enhance the verbalization of analytical results. A goal of his paper was to persuade those who design curricula for early statistics courses to provide a serious introduction to graphical data analysis, at the expense of some traditional material where he feels there is too much emphasis on parametric modeling and its associated inference. Larry showed examples of how statistics jargon is very confusing to the lay person, and even for many students of statistics. By using a number of examples, he claimed that if we teach students to take graphical data analysis seriously, they will be better prepared to communicate the results of statistical analyses.

OUTREACH TO PUBLIC AND SCHOOLS

Several authors discussed statistics communication issues related to the outreach to the public and schools.

Wayne Smith discussed how the general public is an important audience for national statistical agencies and the news media are a powerful tool for reaching this audience. He gave examples of how most journalists are uncomfortable with numbers. Statistics Canada, like most national statistical agencies, places great importance on communicating with the media. *"In a nutshell, statisticians thrive on numbers; journalists thrive on words. Statisticians try to avoid controversy; journalists live on controversy."* Statistics Canada provides training for journalists on specific or general statistical subjects, using chargeable courses, workshops or tailored courses on a specific statistical subject or issue and individual tutoring presenting statistics in a manner which the journalist, as a layperson, can understand. He gave a number of websites dedicated to explaining statistics to writers, such as http://nilesonline.com/stats.

McGuinness and Hooper described how Statistics New Zealand, like many national statistics institutions, aim to increase the use and understanding of official statistics in the wider community. One area where these institutions are increasingly working to communicate statistics is the compulsory education sector. They regard helping primary and secondary school students use and understand statistics as one of the best ways to achieve this aim. They used the relevant quote alleged from HG Wells, 1886-1946 "*Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write.*"

Vermette, Gattuso and Bourdeau found that although statistical concepts are presented in a separate and unrelated way, some high school students develop a line of reasoning with a statistical perspective and are able to grasp the meaning of the data. They have shown that the mode of presentation interacts significantly with the level of difficulties of the questions, and that both of the factors have significant effects on the level of justification of the students' answers.

Philip Holmes-Smith described how he communicates student performance data to school teachers by using the results from national studies of student ability which have been analysed using Item Response Theory (IRT). IRT is a generalized iterative procedure that can be used to simultaneously estimate both the difficulty of items on a test and the ability of those taking the test. Philips's talk gave an overview of this technique and demonstrated its use in measuring student ability, in particular mathematics ability.

Rachel Cunliffe reported on a pilot study into the use and usefulness of instant messaging within an educational context. She explained how instant messaging is a way of sending small, simple messages to other users who are currently online in "real time" and is a rapidly growing medium by which many students are choosing to communicate with each other. Rachel explained that this study will report back on students' general use and perceptions of IM, how this can be

applied to collaborative learning and support, and reflections on how IM could impact on lecturers' time.

Galmacci and Milito presented an experiment based on the use of e-learning to face the problem of guiding large classes of students for lab activities in basic courses of statistics. The students' task was to understand the main characteristics of the "population" and to report results, ensuring that concepts were presented plainly, clearly and properly. E-learning platforms (in particular *moodle*) facilitate the organization of material in different ways to reflect both the kind of support to be provided and the teaching approach. The project is considered a prototype.

Davies and Connor presented examples of improving student communication skills in statistics by using resources that are created from student and teacher involvement in data production. They claimed this can aid the development of thinking skills that enable students to communicate statistics better, both orally and in writing. They gave examples of projects that: encourage students to learn statistical communication skills.

UNDERSTANDING THE LANGUAGE OF STATISTICS

Several authors discussed issues related to understanding the language of statistics and its importance in the communication of statistics.

Petocz and Reid observed that although statistical communication has become a larger part of statistics pedagogy during the past decade, students in servicing courses may have less opportunity to develop statistical communication skills, as they usually take only a small number of statistics subjects. Using an analysis of interview transcripts from students in service courses, they found that although many students who seem to be able to communicate their understanding of statistics to the interviewer, their statements about their statistical communication imply that they are unaware that they are communicating statistically during this process. The authors included in their conclusions that "students should be encouraged to practice explaining their statistical explorations to each other, maybe in the context of group work, and the link between this and communicating statistics in a professional sense should be made explicit."

Sue Gordon examined the questions: "What do statistics teachers believe makes a good student of statistics?" and "What part does the ability to communicate statistical results and ideas play in this judgement?" In this paper, she investigated these questions and suggested answers based on a recent empirical study carried out by an e-mail interview with IASE members from around the world. The responses alert her to the diversity of views on the relative importance of statistical communication held by statistics educators in service courses. She found some teachers propose that communication skills are essential to learning statistics at university, while others do not mention communication. Sue notes that in any discussion on statistical communication, we should be aware of the range of views held by statistics educators themselves, and the range of views that they communicate to students through their teaching.

In a ten year action research project, Niglas and Osula considered it important to develop the students' ability to understand the practical, real life meaning of statistical concepts as well as the ability to communicate statistics in both "statistical language" and "everyday language." The authors claimed that behind complicated statistical terms and formulae are simple and logical ideas which we actually use in our everyday reasoning.

Milo Schield gave the final talk which discussed statistical prevarication – the art of straddling both sides of an issue or idea – involving a statistic. Milo asserted that statistical prevarication is all too common in statistical education, in teaching and textbooks, and claimed that statistical educators may be responsible for much of their students' misunderstanding about conditional probability, confidence intervals, statistical confidence and statistical significance.

SUMMING UP

A general theme emerging from the papers was the general recognition of the need for statistics students to acquire good communication skills. How this might be achieved was discussed by several authors. It was pointed out by Francis that if we want students to write effective reports on statistical analyses, we have to include specific training on report writing as part of our subjects. Lipson and Kokonis found that report writing was not as straight forward for students as many might think. Forster, Smith and Wild who used a structured approach to

learning to write reports in first courses, gave a caution that this technique could limit creativity. Peck pointed out, "Good statistical communication, like so many other things in life, improves with practice."

The importance of making effective use of good graphics was emphazised by a number of authors, for example Martin and Weldon. Many make use of graphics available in standard packages, but some, like Cumming, Fidler and Green, have devised unique visualisation tools to help users gain insight into the structure of their data and hence better communicate patterns and relationships in the data.

The worth of using context was highlighted by several authors. Peck, for example, made the point that "It is the interpretation of results and the communication of the results in context that require good statistical communication skills."

The role of the official statistics agencies in the communication of statistics was discussed by several speakers. Smith explained how many citizens get their statistical information from the media, while the media get theirs from the statistics bureau's official bulletins. It is seen that the statistics agencies can play an important role in providing information in the form of practical information, datasets and training.

The use of projects was seen as a good way to help encourage students to learn statistical communication skills. MacGillivray claimed that communication was integral in the process of carrying out a project. Davies and Connor from their work in the *CensusAtSchool* project, reported that students who have been exposed to this approach are more data-aware and show improvement in writing-up statistics projects.

Some researchers see that informal discussions can be helpful in developing communication skills in statistics. For example, Petocz and Reid feel this can encourage students to constitute the meaning and usefulness of statistics for their discipline and as a precursor to more formal communication.

In conclusion, it is worth noting that in a review of statistics at Australian Universities, Statistical Society of Australia Inc. (2005), it was stated that in recent years,

"*the requirement of many employers is less for graduates with specific technical statistical skills than for students with a reasonable level of all round quantitative reasoning skills combined with a flexible approach to problem solving, the ability to handle basic computing and data management packages and, above all, team working and communication skills.*" (p. 24)

REFERENCES

Fienberg, S. E. and Stern, P. C. (2005). In search of the magic lasso: The truth about the polygraph. *Statistical Science*, 20(3), 249-260.

Statistical Society of Australia Inc. (2005). *Statistics at Australian Universities: An SSAI-sponsored Review*, http://www.statsoc.org.au.

Papers presented are found at the meeting website:

Statistics Education and the Communication of Statistics, Sydney, Australia 2005
http://www.stat.auckland.ac.nz/~iase/publications.php?show=14.